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CONTENTS

PAGE

Polymaths: Technicians, Specialists and Genius—
CHARLES S. SLICHTER 97

A "New Deal" for Minnesota 109

An Unscientific Incident Concerning a Scientist and a Scientific Society 110

Report of Committee on Award of Grants in Aid of Research ... 110

Contact Potentials Between Metals and Certain Dielectrics—
GEORGE H. SHEPARD 111

Minutes of the Meeting of the Executive Committee of Sigma Xi, Chicago, June 21, 1933 114

In Memoriam—Harold De Forest Arnold 118

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SIGMA XI QUARTERLY

Vol. XXI SEPTEMBER, 1933 No. 3

POLYMATHS: TECHNICIANS, SPECIALISTS AND GENIUS*

CHARLES S. SLICHTER

It was almost sixty years ago that Von Helmholtz began to lead Germany to a better industrial future and to guide her in the development of technical education. Germany, it is true, possessed a number of good "Polytechnicums," but their scientific and educational equipment did not meet the ideals of Helmholtz. He traveled about Germany preaching to the text "Science is the best Technology." He applied this slogan with vigor to the problem of the rapidly growing industry and technology of the new Germany. Professorships at the technical high schools were not then thought to be equal in honor to the professorships in the universities. Helmholtz believed that all sections of pure and applied science should advance abreast in unified formation and equal honor. He no doubt was envious of the dominant position of the Swiss Polytechnicum at Zurich. The slogan "Science is the best Technology" fixed the direction and the trend of Germany's ambition. The Reichsanstalt was reorganized about 1887 with Helmholtz at its head. That was a practical and concrete example of the Helmholtz policy. "Science is the best Technology" is a dictum that should not be forgotten. Helmholtz did not undervalue the services of technicians and mechanicians—he was one himself—but to him technicians had little to do with technology. Technology, to be worth while, must be indistinguishable from science and the practitioner must first of all be trained and inspired by the methods of science. Technique there must be, but the kind of technique so universal at that date, both in medicine and engineering, based primarily on rule of thumb and current practice, he valued but lightly. He turned his public influence against the empirical concept of technology and the growing narrowness of the specialists. Helmholtz was familiar with more than one great field of learning. He taught the lessons he had learned from the vast variety of his experience and from his profound knowledge of the history of science.

Of course, in ancient times, all engineers were scientists and all scientists were masters of many fields. The etymology of the word mathematics illustrates this. Mathematics does not mean mathematics; it means *science*, or, more accurately, it means "general science" or "all science." Nevertheless, and perhaps unfortunately, there is such a thing as specialization, and also such a thing as narrow specialization. We not only have "scientists," we have

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"chemists." We not only have "chemists," we have "colloid chemists." We not only have "colloid chemists," we have "inorganic colloid chemists." We not only have "inorganic colloid chemists," we have "areosol inorganic colloid chemists," we not only have "areosol inorganic colloid chemists," we have "high temperature areosol inorganic colloid chemists," and so on indefinitely until the scientist is fractionated to a single paragraph of his doctor's thesis. Science has become an asylum with many cells and with many minute padded cubicles for the violent cases. But nature is constantly breaking all bonds and delights in liberating supermen with freedom to pace all corridors of knowledge. Aristotle gave devotion to all the philosophies. Such a man we call a *polymath*, again using the root meaning present in the word *mathematics*. The ages have given us many polymaths and not a few in whom technology and pure science have been joined together. It is Archimedes, of course, that should be canonized as the patron saint of scientists, as well as the patron saint of engineers. He was the first to announce the principle of moments and the properties of the center of gravity. This alone would make him the Adam of the engineering paradise, for many a modern engineer makes his living out of the principle of moments alone, as Helmholtz delighted to expose. But of course Archimedes did more than that. He was the wizard of the ancient world—the Newton, the Einstein, the Edison, the Marconi of that day both in fact and in popular acclaim. When he exclaimed: "Give me a place to stand and I will move the world," he was speaking as an engineer, with the well-known self-confidence and brusque assurance of that profession. At his death, surprised in his study by the Roman soldier, it was not the engineer, but Archimedes the scientist that spoke and begged the Roman to stay his sword but a moment that he might bring his demonstration to bear and not leave his theorem incomplete. We should canonize this martyr as the patron saint of both science and technology. In the cathedral of science I suggest two chapels; one to Saint Archimedes, the patron of engineers, with a painting above the altar showing Archimedes boldly demanding a place to stand that he might displace and disjoint the earth; and another chapel to Saint Archimedes, the patron of science, with a panel above the altar depicting Archimedes face to face with his murderer, pleading that his thought be not left imperfect.

The group here present probably holds views concerning human ability that I am too old-fashioned to understand. You probably adhere to the latest theory that genius is not made nor even possessed by the individual, but is the gift of the public and the creation of humanity at large. Shakespeare, Napoleon, and the others were not supermen in themselves, but only the creatures of their own and the following generations. If I confine myself to the presentation of verbal pictures, you, with your modernistic philosophy, can draw the proper conclusion and I, with my old-fashioned ideas, can adhere to my ancient philosophy. A few of you may embrace both contradictory views and allot to every superman the share that is his own and the part that the public has done to him. Compromise in contradictions is a much practiced modern art.

As we run down the centuries from the apostolic age of Archimedes, we arrive at that amazing galaxy of polymaths characteristic of the renaissance. Leonardo seemed to be able to know and to do everything; in fact, Leonardo constitutes such a well-known example that I must not detain you with its consideration, but there were many others who were almost as polymathical. It was a common thing for a man to start out in a career quite remote from science, later to be rescued by an irresistible impulse, often originating in a trivial incident. Euler was destined for the church, but switched to medicine, then to mathematics. James Bernoulli was to have been a clergyman; John Bernoulli started out as a business man; and Daniel Bernoulli actually became a physician and at one time was professor of anatomy and botany at Basel. John Wallis, the mathematician, was the prosperous rector of St. Martin's ultra-fashionable parish, and the author of the best English grammar of his time.

Sir Christopher Wren, known to every schoolboy as a prodigy of universal science, is the one we all would bracket with Leonardo for a first prize in Polymathics. He was professor of astronomy at Oxford and an original experimenter in anatomy and physiology and in the transfusion of blood from one animal to another. He was complimented by Newton for his mastery of mathematics. He was the originator of a microscopic study of insects. He was an artist and a poet and a member of Parliament for twenty years. His side lines were a complete plan for the rebuilding of London after the great fire of 1666, the construction of the military defenses of the city, the architecture of halls and towers at Oxford and Cambridge, and the building of St. Paul's Cathedral.

Newton had more fun in the thirty years he was warden and master of the mint and busy revising the king's coinage than he had during his thirty years on the faculty of Cambridge. Helmholtz started his career in medicine and physiology and found this preparation won him a unique position in physics. Thomas Young, the physicist and mathematician, was the leading physician of his day, with medical degrees from Edinburg, Goettingen, and Oxford, was the best dressed and best tailored man of Bond Street and the social favorite of the ladies. He was a linguist and orientalist and the first scholar to decipher Egyptian hieroglyphics. La Grange planned a literary career and Huyghens started life as a lawyer. Some geniuses have been polyglots as well as polymaths Hamilton mastered four languages at age four (including the Iliad of Homer) and had mastered fourteen at age fourteen. Euler was a notable linguist and literary critic and had so keen a memory that total blindness neither stopped his studies nor interfered with the most complicated calculations. Perhaps most curious of all is the case of that foundling who called himself D'Alembert. He studied all three professions—divinity, medicine, law—and was a musician and a writer and a critic of note and a philosopher and a conversationalist welcomed in all the brilliant salons of his day.

Men of multiplex genius like those I have listed have no trouble in solving engineering and technical difficulties and many of them have been great inven-

tors. Huyghens invented the pendulum clock and the coil spring and Euler won a prize on the masting of ships. The thing that genius seems to need most is a challenge—it is an accident whether the challenge comes from pure or applied science or from the perplexities of church or state. You will agree, I think, that inventiveness is not departmental and the imagination of men does not naturally explore in paths or lines, but has a natural tendency to spread and expand in all dimensions of knowledge.

I intend to follow the plan of Plutarch and present the substance of my discourse through the media of two contrasting characters. The first of these is Lord Kelvin, or Sir William Thomson, as he was known for much of his life. When I was a college student and was constantly required to study Thomson and Tait, I must confess that I felt little enthusiasm or affection for the book or the man. The treatment of the same topics in the French treatises was so much more elegant and lively that Thomson and Tait seemed dry and the personalities back of the writing hardly seemed touchable. But in later years I discovered that Lord Kelvin was one of the most human and lovable of characters. He never lost his youthfulness nor the simplicity and naturalness of spirit. His nervous ectasies in discovery and his delight in invention and mechanical devices were always those of a boy. He never outgrew the enthusiasms of his college days. He was fortunate in his early training, for his father was professor of mathematics at Glasgow. The father had no small part in giving a modern trend to his son's scholarship. It was not the fashion then to give much attention to what was going on in science on the continent of Europe. Cambridge was quite self-satisfied and self-sufficient in the conduct of the Mathematical Tripos, which it was content to retain as a gentleman's game quite insulated from the new learning. The Tripos, like fox hunting or polo or cricket, was to be taken most seriously, of course, for sport is the most serious of all human efforts. Your wife will confirm me that a misplayed card in your bridge is much more serious than a misplaced syllogism in your logic. For that very reason the game of the Tripos must not be permitted to share in the joy and in the adventure and freedom of productive scholarship. A century ago Cambridge knew how to play the mathematical game to perfection and even to this day the reform of the Tripos is not perfect. But James Thomson, the father of Lord Kelvin, was bound by no examination tradition. The son of a small farmer of County Downs, his poverty made Glasgow University the best he could afford and even then he had to be late in entering. Thus he was able to short circuit the Cambridge conservatism. The early 19th century was a prosperous and exciting time in mathematics—analytical methods were superseding other methods and the general superstructure of analysis was being carefully fabricated. La Place was at the height of his fame, Legendre had written memoirs which were to lead, in the hands of Jacobi and his successors, to a new domain of science, and "Gauss had begun his stately march of discovery." The world was ready for a new group of adventurers—Poisson, Fourier, Cauchy, and the like. The memoirs and treatises of the continental writers were eagerly procured and studied by James Thomson; he had escaped the Cambridge

cramps. At age twenty-nine he was professor at Belfast and in 1832 at age forty-six he was called to the chair at Glasgow. He was free in his teaching, writings and text books, to make continental mathematics known to his students and to the English public. His children, William and James, learned from him at Glasgow so that from early years they knew that there were mathematicians later than Euclid and Newton, and in fact that they were living in an exalted epoch of the exact sciences. The seven years, 1834-1841, William Thomson spent at the University of Glasgow. The temper of the university of that day is sufficiently described by the fact that it was the university of Adam Smith, James Watt, and Thomas Reid. The quality of the training it offered to young Thomson is illustrated by an incident of 1840. The father and his two sons, James and William, spent the summer of 1840 in a tour of Germany. All study except that of German was to be taboo. But William had just begun Fourier's Theory of Heat. He surreptitiously took the book with him and finished it in a fortnight. He found that an attack on Fourier by Professor Kelland was not justified and the discovery required him to confess his sin to his father. He was promptly forgiven and from Frankfort he sent to the Cambridge Mathematical Journal his first paper on Fourier's method and soon followed it with another. Next year at seventeen he entered Cambridge where he at once became a great favorite and made many lifelong friends. In sports he won the silver sculls and many other trophies and contributed the tooting of the French horn to the CUMS. Ten papers, all on the flow of heat, appeared during his first two years at Cambridge. He was the much discussed favorite for Senior Wrangler, but he had put too much time on the mechanics of La Place and of La Grange and hence surprised his friends and even the Moderators by taking Second Wrangler. Notwithstanding this concession to the Cambridge system, he, a few days later, became Smith Prizeman and won a fellowship. That summer he visited Faraday in London and spent the rest of the summer in the laboratory of Regnault in Paris. Then, only one year after graduation, he was called to the chair of Natural Philosophy at Glasgow, a position he was destined to hold for more than fifty years. He now had the freedom he long had coveted and the famous wine cellar at the old university became the first laboratory of physics in Britain and probably the first laboratory in the world open to undergraduates. At that date the great job seemed to be the substitution of quantitative for qualitative work in nearly all domains of physics. It is difficult to realize now the primitive state of affairs at that time. Ampere would give measurements of electrical resistance in terms of a piece of copper wire kept in his laboratory. No one could check or compare his work with another. The new professor at Glasgow was soon making a beginning in the design of a variety of quantitative instruments, many of which were destined to make him both wealthy and famous. He was by nature an engineer. He wished to make things work and to be of use. The improvement of telegraphy and the hot discussion over the possibility of submarine telegraphy absorbed his attention. There was much difference of opinion, especially concerning the electric voltage that should be used. Fortunately Thomson's low voltage ideas won the day, and when the first Atlantic cable was laid he was not only responsible

for the design of the cable and its instruments of test and operation, but was on board ship throughout the laying of the cable and throughout the laying of its two successors. In these early years, as chief engineer to the cable company, he helped in everything that had to do with the process, such as the design of grappling hooks, splicing tools and tension control. This is not the place to give the history of the early cables, but no one without the perseverance of the English could have been successful. The first two cables from the Azores to Brazil were a total loss. The first was lost just as the Brazilian shore was reached, and the second went down with ship and crew when partly laid. For many years the laborious manufacture of the cables received the personal supervision of Chief Engineer Thomson. A compartment in the night London Express was always held for him and this famous train was many times kept waiting for special apparatus from White's, the instrument maker. The frequent commuting between Glasgow and London had principally to do with the cables and his engineering devices such as the famous compass for steel ships and the sounding apparatus. Kelvin personally pushed the sale of these with the shipping interests and fought for their adoption with the bureaucrats of the navy, and actively defended the patents in court. He was willing to patent anything. He became very wealthy, partly from his share in the companies making the cables and the instruments and other devices. His fame among the common people was due in great part to his invention of a water tap known as the "Kelvin Tap." Millions would never have heard of his name if it had not been for this non-leakable contraption and the water tap, of course, was all they did know about him. He was shocked and indignant when his friends tried to joke with him about the Kelvin Tap. He thought a non-leakable tap quite as important for many people as a mirror electrometer. He was delighted to be thought clever enough to invent a good household device. His example and his public utterances express an attitude towards engineering quite the obverse of that of Helmholtz. At an address before the Institute of Electrical Engineers in 1883 his text was: "The life and soul of Science is its practical application." This dictum does not exactly deny that "Science is the best Technology," but it at least puts the Helmholtz saying in reverse. The millionaire inventor of a water tap could hardly say less. But Kelvin was essentially a mechanical philosopher. He sought mechanical models for all his concepts and for all the phenomena of science. Although a deeply religious man in the conventional sense, no naturalist of his century adhered more fanatically to a mechanical explanation of the nature of things. When the new physics was putting forth its new and almost mystic conceptions during the last years of Kelvin's life, he became a vigorous and embittered opponent of the new ideas. Although he lived until 1907, he never accepted Clerk Maxwell's electrical theory. He fought Rutherford and all his modern theory of radioactivity. To him all phenomena had to be strictly mechanical—he could only think in terms of springs and wheels and gadgets.

During all his many activities and throughout the preparation of his prolific scientific writings, Kelvin the man was always dominant. He never ceased

scientific productivity for a moment. At his country estate at Netherall there was as much good science in incubation as at Glasgow. Even on his large yacht, the *Lalla Rookh*, there was always science in the making and, as at Netherall, he often had assistants with him for this very purpose. He was never without his specially made large green note book; he had game pockets put in the back of all his coats to hold the "green book" and he filled several of them every year. Science to him was play and it was always mixed with his other play. His favorite pets, his dog and his parrots, shared his research with him. Parrots are notoriously long lived, but it took two of them, Doctor Hookbeak and Doctor Redtail, to outlast Lord Kelvin. A favorite diversion at Netherall was to dictate to two secretaries on two different scientific topics at once and at the same time conduct a singing lesson for Doctor Redtail. The parrot, however, was quite as much attracted to the aside remarks made under his breath by the faithful butler as to the formal lessons of the master, for the dinner guests were often shocked upon the late arrival of the host at table, to hear Doctor Redtail exclaim, "Late again, Sir William, old boy!"

I doubt if anyone has ever received as many honors, or as many memberships in scientific and engineering societies, or was as universally acclaimed as Lord Kelvin. The universities ran out of honorary degrees. The University of London had never conferred an honorary degree, but it felt obliged to make an exception. Heidelberg, looking over his long list of honors, hit upon the happy novelty of conferring on him tne degree of Doctor of Medicine. This certainly ought to give Lord Kelvin a standing among the Polymaths.

While Kelvin was building his scientific and worldly fortune and amassing the multiform glories and decorations that went with his achievements, another great Englishman was working in almost complete seclusion, remote from centers of learning, and unknown and unrecognized by the society he was serving. Kelvin came from a family of scientists, Oliver Heaviside came from a family of engineers. His uncle was Wheatstone, the practical founder of modern telegraphy, and his father and brother were among its early promoters. Soon after leaving school, Heaviside obtained a post with the Great Northern Telegraph Company, which he held for several years. During this period he contributed papers to the *Telegraphic Journal* and to the *Philosophical Magazine*, papers that were much above the average in ability and originality. For example, he showed in 1873 that quadruplex telegraphy was possible, but he took out no patents, nor did it ever occur to him to profit from his profound studies. But the next year, at the early age of twenty-four, increasing deafness required him to retire, and he spent the rest of his life as a scientific hermit at Torquay. He now devoted himself to mathematical studies in electricity and its applications. His papers gradually became more and more technical and more and more exacting and more and more difficult to understand. At a time when Lord Kelvin was publishing everything in the scientific journals, even lecture notes primarily for his students, and printing at length many papers which unfortunately were but repetitions of results obtained previously by others, the hermit of Torquay was experiencing the greatest difficulty in securing publication of his work. There were few editors

or referees of the technical journals competent to understand them. Hence the editors required his papers to be cut, so that many necessary and elegant mathematical links were left out and the work so mutilated that it was difficult to follow and to appraise. Fortunately one or two scientists, Oliver Lodge, and Professor Perry, had discerned here a mathematical physicist of superior talent and through their aid some of his best work was saved from the waste basket. Heaviside communicated to the Society of Telegraph Engineers (now the Institute of Electrical Engineers) a paper solving the problem of the electrostatic and electromagnetic interference between overhead parallel wires. In 1887 he published his method of measuring mutual inductance. He was the first to solve the problem of high-frequency resistance and inductance of a concentric main. From the practical point of view, he laid the foundation of the modern theory of telephonic transmission, a theory that has proved a veritable gold mine for the practical worker in telephony. He showed that the difficulties arose from the different attenuations and velocities of the component waves which carry the currents. He showed the lines on which undistorted waves could be transmitted. He let others take out the patents and mine the gold. Kelvin in money matters was true to his Scotch inheritance. Heaviside said that the question, "Will it pay?" never interested him. He wished to be known, he said, as a "philanthropist"—as a free giver of the best that was in him. His work has saved every civilized country millions and millions of dollars in the cost of its telephonic and wireless developments. While all England was acclaiming Kelvin and while Kelvin numbered his friends by the scores of scores, the only intimate scientific friend of Heaviside was Doctor Searle of Cambridge.

For more than a generation he lived in his villa at Torquay absolutely alone and almost unnoticed. The oaken door of his mansion was nailed with numerous notices of executions for non-payment of taxes and similar delinquencies. A few times a week a woman of the countryside brought him milk and simple food and his laundry. He was living on a pension of only two hundred pounds generously awarded by the Royal Society. Within the mansion he might perhaps be climbing the spiral stairway to his study. He was always carefully groomed and immaculate in his linen and broadcloth of the seventies. But this aristocratic and handsome figure did not seem alone, nor did he feel a grudge against an unappreciative world. On the walls of his study were hundreds of portraits of the scientific worthies of his century and endless stacks of books seemed to constitute the framework of the house itself. Through the windows there entered at all hours the matchless beauty of the bay and the curving shores of Torquay, and through them came all the changing lights that the sun or the moon and the clouds and the waves could mingle for his sensitive and appreciative eyes. There on the tables and shelves were the visible results of a busy and devoted life—thousands of pages of unpublished manuscripts, a serial record of many happy hours. Now the Royal Society has these papers, and from them the editors say we shall know much of the foundations of his scientific processes heretofore so darkly hidden in the skeleton outlines printed in his lifetime. But it is gratifying to know that

in his last years he was one whom every electrical engineer delighted to honor. He received the first Faraday medal and many other notable laurels. His reputation today, seven years after his death, is growing apace. To verify all Heaviside's reasoning and to examine and explore the validity of his mathematical methods, will provide ample work for many mathematicians and physicists. He himself took his greatest satisfaction in the discovery of the increase of mass of a moving electric charge and in the prediction of the existence in the atmosphere of what we now call the Heaviside layer.

The deafness of Heaviside kept him from attendance at scientific meetings and from the benefit of the advice and stimulus of fellow workers. Lord Kelvin attended all meetings from beginning to end. He was always bobbing up in multifarious discussion with the activity of an irrepressible small boy at a birthday party. No meeting seemed quite the same after Kelvin's death.

There was no debate about the burial place of Lord Kelvin. He was entombed at Westminster by the side of Newton. No such public honor could, of course, be expected for the hermit of Torquay. Nevertheless, as the years roll on, the power and the originality of Heaviside's work more and more emerge. Perhaps, after all, the popular judgment concerning these contrasting characters may not be infallible nor final. We may be sure that the popular acclaim of the one, and the public neglect of the other, will have little to do with the ultimate appraisal of their scientific worth. In the long record of Time's reversals of contemporary judgments, we may yet read that Kelvin, the mathematical physicist, is assigned final honor primarily for his engineering courage in the development of submarine telegraphy, and that Heaviside, the electrical engineer, is awarded immortality for his sagacity in mathematical discovery. Time is the greatest of all jurists. Its judgment in this matter has not yet been handed down.

Have the days of the polymath come to an end? Can scientists of the all embracing interest and accomplishment of Saint Archimedes continue to flourish? The popular answer seems to be no; this is the age of specialists. But close examination does not lead to this result. The modern specialist is a manufactured product. We make each year the number of specialists our civilization requires. We produce, say, 20,000 machinists, 10,000 engineers, 7,000 lawyers, 5,000 physicians, 2,000 doctors of philosophy. If the demand be greater, we produce more. We produce chemists and engineers and physicists to equal the demand. But above the specialists and above all the human merchandise of university mass production, there is another group, masters of knowledge like Kelvin, Helmholtz or Heaviside. These are not manufactured nor standardized products. Of these there are never enough and the supply is beyond our control. Above these masters there is another class—the men of true genius like Archimedes, Newton, La Place, Darwin, Einstein. This group is unique and individual down to its last characteristic. One of them is equally likely to appear either as a polymath, or as a genius of narrow form, just as nature happens to decide, and quite as well in the present age as in ages past. The specialist deals in facts, multiplied without end. The genius deals not in facts, but in perplexities and contradictions and paradoxes.

Darwin was not a genius because he industriously accumulated an encyclopedia of facts, but because of the philosophical revolution he brought about by his spiritual and almost mystical interpretation of those facts. Kelvin conformed to conventional truth; to him no great novelty of thought was tolerable. The then existing mechanical principles constituted the true faith worthy of all men to be believed—even the electrical theory of Clerk Maxwell must be bitterly opposed as unorthodox and dangerous. Genius challenges conventional truth. It invokes allegiance to unrealized principles, to principles that often must be fought for at great risk. The fundamentals of knowledge in any age are few and not infinite in number—few enough, perhaps, that a polymath may uncover and master all of them. These are the men whom each age awaits, but who appear only at culminating epochs in the affairs of men. Their mission is to question certainties, to "doubt all things that can be doubted" and to bring us mysteries. It is something of life to learn that there are mysteries that shadow it; it is something of life to know that there are truths still hidden even from the prophets.

But these are old fashioned views, and I should not urge them upon you. In the modernistic scheme of things, supermen are the creation of the multitude and you can contend that the contrasting characters I have presented to you prove the case. What does it matter if Kelvin could not find his way into the new conceptions and mysteries of modern science? Did he not amass a fortune? Was he not universally acclaimed and decorated? Was he not knighted and raised to the peerage and buried in Westminster? The Cathedral of Science is not made of stone, but is a vision, perhaps an hallucination, of the public. It matters little to whom we dedicate its immaterial chapels—saints or sinners, simple men or supermen. It is only our belief and our concerted faith that counts. If we light the candles before a favorite altar, there seeking to be refreshed and sanctified, it only matters that the place be dedicated to one whom the crowd claims has attained unto glory and whom our faith declares is worthy of adoration.

The contrast in the two characters I have presented extended even to their spiritual lives. To Kelvin religion was a concrete and orthodox and bounded central zone, surrounded by a vast expanse of scientific truth, which to him was the world of reality. To Heaviside all of this stood in reverse: Science was a growing, but shifting, central area, a make-believe world, circumscribed by a border of mystery, but beyond this zone lay an endless spiritual domain, to him the true world of reality. In his solitude at Torquay his eyes met first the curving shores of the sea, then the rhythmic pulsing of the waters, fading away to the rim of the horizon, on and on into the haze, but emerging again, clearer and clearer to his inner sense, into a spiritual realm of reality.

Heaviside knew that there are Two Worlds.
One is the World of Science, which Kelvin so naively and so falsely deemed the World of Reality.
For the room of this world, man imagines a Space, and, in the space, a Frame of Reference for Events.

To mark an event, he makes an Arrow, happily called Time's Arrow, for he says it leads from that which now is to that which is to come.

The arrow is trued and checked against the frame and the trend of the arrows he calls Causality, and the metrics of the arrows are the measures of science.

To this make-believe world, man adds the artefacts and the imaginings and the changeful theories of science and also the Averages of many measures.

He writes down his findings and in his audacity calls them the Record of the Nature of Things.

All of this and nothing more makes up the World of Science.

Heaviside knew that there is a greater world, the World of Personality.

The room of this world is not the frigid space of science, but the warm continuum of the Great Presence.

Within this world is fixed a three-fold frame: Truth, Beauty, Virtue.

Also, for each personality, there is a Time's Arrow—a Golden Arrow—trued and checked against the frame of Truth, Beauty, Virtue, and the trend of the arrows we call Purpose.

The metrics of the arrow are not the measures of science, but the countings and weighings of Spiritual Values.

The Great Presence is mindful of the arrow, for as that golden vector moves and orbits in a spiral of life, there exists a Best Way and many less perfect ways, and the Great Presence would guide and shield that orbit in the way that is best and lead it more and more to its own perfect purpose.

This is the spiritual creed of evolution, and it holds alike for galaxies and for men.

At last, for each of us, the World of Science crashes and comes to naught again, and we call it Death.

But the world of the Great Presence does not end, for the golden arrow courses on, still trued to the frame of Truth, Beauty, Virtue, on and on in the most travelled and best known domain, which we so naively and so falsely call the Great Unknown.

This is the domain searched by philosophers and prophets, by Plato and Saint Paul and all the saintly mystics.

This domain to Heaviside was, in truth, the World of Reality.

To the Honorable William James Mayo, Regent of the University of Minnesota, Surgeon and Chief of Staff of the Mayo Clinic and co-founder of the Mayo Foundation: for his achievements in the applied sciences of surgery and medicine, for his support of productive scholarship both in the medical sciences and the sciences basic thereto, and for his leadership in the development of scientific means for the preservation of human health and life; the Minnesota Chapter of the Society of the Sigma Xi gratefully presents this testimonial of appreciation

Donald G. Paterson
Chapter President

Frederick B. Kett
Chapter Secretary

The twenty ninth day of May one thousand nine hundred thirty three

A "NEW DEAL" FOR MINNESOTA

The Minnesota Chapter has initiated an entirely new custom for the chapter, and, as far as is known, for the society of the Sigma Xi in originating and putting into practice an unusual form of recognition of distinguished service in furthering science and scientific research in the State of Minnesota. At the annual meeting at the close of the year two scientists well-known in the state and, indeed, throughout the country were handed illuminated testimonials which set forth their accomplishments in their particular field and expressed the appreciation of the fellow workers in Sigma Xi. The two scientists selected for the honor were Dr. William James Mayo of the famous Mayo Clinic, and Dean Guy Stanton Ford of the Graduate School of the University of Minnesota.

The illuminated certificate presented to Doctor Mayo had the form illustrated in the facing photograph.

A similar certificate handed to Dean Ford read as follows:

> "To Guy Stanton Ford, Professor of History and Dean of the Graduate School of the University of Minnesota, for his effective efforts in behalf of productive scholarship at the University, in the State, and in the Nation, for his service to international cooperation in science, and for his brilliant contribution to the 1933 Sigma Xi Symposium, the Minnesota Chapter of the Society of the Sigma Xi gratefully presents this testimonial of appreciation."

The testimonials were presented by Dr. Louis B. Wilson, president of the national organization.

The University of Minnesota Press has published in pamphlet an address given by Dean Ford on "Science and Civilization" in the Northrup Memorial Auditorium. This was the concluding lecture of a series of four on the topic "Science and Human Welfare" given to the public under the auspices of the Minnesota Chapter.

AN UNSCIENTIFIC INCIDENT CONCERNING A SCIENTIST AND A SCIENTIFIC SOCIETY

The recent death of Dr. William H. Anthony, of Plainfield, N. J., brought to light a story of the finding of his Sigma Xi key which he lost several years ago. He was calling on a patient at Springdale at the time. On returning home he missed the key and despite diligent search never recovered it.

The day the local banks were closed by proclamation Mrs. Anthony through a chance meeting of Doctor Cushing, a veterinary surgeon, in the office of Dr. Julian P. Linke, learned of the finding of the key.

Doctor Cushing, who at the time did not know Doctor Anthony, told her he was called to a farmer's home near Springdale some time ago to attend a sick cow. He met George Stine, who was attracted to a pin he was wearing. He asked him what it was. After being told he said he had "one of them things."

Going to a cigar box hidden behind a mantelpiece in the house, he brought out a Sigma Xi key. Doctor Cushing found Doctor Anthony's name inscribed on it. Mr. Stine said he found it in the road near his home some time before.

Doctor Anthony received the emblem at the University of Pennsylvania in 1903.

REPORT OF COMMITTEE ON AWARD OF GRANTS-IN-AID OF RESEARCH

The Committee received and considered twelve applications for grants-in-aid and took action as follows:

Charles Ernest Braun, associate professor of organic chemistry, University of Vermont, $150 for continuance of the study of the relationship between guanidine structure and hypoglycemic activity.

Fred Wilbert Emerson, professor of biological science, New Mexico Normal University, $60 for study of the adjustment of plants to the peculiar life conditions of the white sands near Alamogordo, New Mexico.

Edwin T. Hodge, professor of geology, Oregon State Agricultural College, $100 for analytical work in connection with a large suite of Oregon rocks.

C. J. Krieger, professor of astronomy, University of St. Louis, $100 for publication of a paper on "Preliminary Table of Lines in the Spectrum of Delta Cephei."

Ruth Marshall, professor of zoology, Rockford College, $100 for continuance of work on hydracarina of Wisconsin.

T. L. Smith, professor of zoology, College of the Ozarks, Clarksville, Ark., $150 for research on a species of lepidoptera-galleria mellonella L.

W. R. Whitney,
Gary N. Calkins,
Harlow Sharpley.

CONTACT POTENTIALS BETWEEN METALS AND CERTAIN DIELECTRICS

GEORGE H. SHEPARD
Purdue University

In connection with certain engineering and industrial work, the writer needed to know the contact potentials between metals and certain dielectrics in the air at temperatures ranging from atmosphere to 1300° C. or over. Considerably to his surprise he was unable to find the information in the literature and therefore had to determine the values himself, and therefore supposes that his results may be of interest to others.

The apparatus used by the writer is shown in Figure 1. The dielectric was contained in the crucible shown in longitudinal section. The platinum wire which passed into, and heated, the dielectric was calibrated for current and temperature, so that the temperature was determined by the reading of the ammeter A.

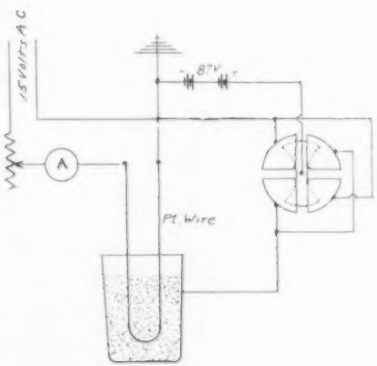

Fig. 1

The platinum wire contained no more than a trace of impurities; and the dielectrics not over a fraction of one percent.

Difficulty was immediately found, in that it was impossible to get consistent or repetitive readings of potential difference between the platinum wire and the crucible against the temperature of the wire.

The only previous experimenters of whose work along similar lines the writer was able to find records are Alfred Coehn and Alfred Curs. They report that it was necessary to work in high vacua in order to obtain consistent results. ("Residual Electricity, the Potential of Metals Toward Dielectrics." *Z. Physik*, 29, 1924.)

The writer noticed that, the longer the dielectric was heated by the wire, in the course of experimentation, the less the irregularities of the readings became; and this fact led them to try prolonged heating of the dielectric at high temperatures prior to experimental runs; and by this method consistent and repetitive readings were finally obtained.

The results with SiO_2 are shown in Figure 2. In order to get consistent and repetitive readings with SiO_2, it was necessary to hold it at a temperature of 650° C. for forty-four hours immediately before the first run and thereafter between runs; and during any short time which might intervene between

taking the sample out of the oven and starting a run, to keep it in an airtight dry container.

When the SiO_2 was so thoroughly dried, its ohmic resistance became very great, so that a long time was required for charges to accumulate. In order to obtain consistent and repetitive readings, it is necessary, after the apparatus has been set for any given current, to let it stand, until the electrometer attains a steady reading and holds it for at least ten minutes.

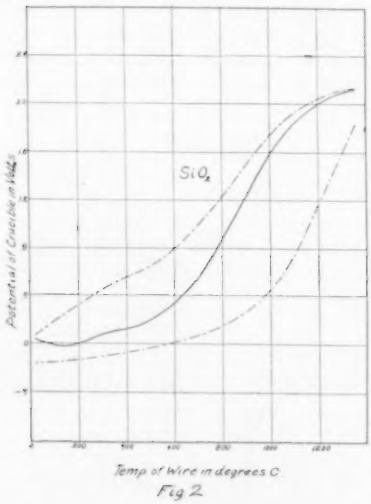

Fig 2.

Even when these precautions are taken, the readings may be made worthless by air pockets in the dielectric, so that it is necessary to guard carefully against them.

As to the usual assumption that the relation between temperature and contact potential is a linear function, in the results as shown for SiO_2 in Figure 2, this does not hold below 450° C. Above that the equation of the straight line through the approximately straight portion of the graph is

$$E = -2.1 + .0028\ T,$$

where E = potential in volts and
T = temperature absolute in degrees C.

At 1175° C. the potential appears to become asymptotic to a maximum value.

To anyone working with these materials in air, the amount of variation from the graph of Figure 2, to be expected, will be of interest. The writer therefore indicates the limits of variations found by him by the dashed and dotted (— — — —) outline of the field in Figure 2.

Moisture in the samples seems to be the most plausible explanation of the wide variations from the final graph. The variations found at temperatures so much above 100° C. could not have been due to ordinary moisture in the air entrained in the sample. Since the writer used amorphous silica the moisture could not have been water of crystallization. It therefore seems probable that it was water very firmly held by adsorption and occlusion. It seems not to have been generally recognized that moisture, other than water of crystallization, could be so firmly held by an oxide, even when the latter is in a finely divided state.

The atmosphere in the writer's laboratory was very little subjected to contamination from any cause, so that in industrial plants even wider variations due to acids in the atmosphere might be expected.

In the writer's experiments the contact potential throughout the range of temperature investigated definitely tended to rise, as the SiO_2 was more thoroughly preheated.

Al_2O_3

The results with Al_2O_3 are shown by Figure 3. In order to get consistent and repetitive readings with Al_2O_3, it was necessary to hold it at a temperature of 700° C. for twenty-four hours, and otherwise to take the same precautions as with SiO_2.

As to the usual assumption that the relation between temperature and contact potential is a linear function, in the writer's results as shown for Al_2O_3 in Figure 3, this does not hold below 700° C.

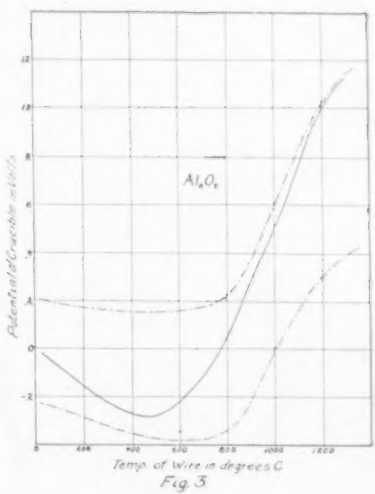

Fig. 3

Above that the equation of the approximately straight part of the graph is,

$$E = -2.38 + .00236\ T$$

where E = constant potential in volts
T = temperature absolute in degrees C.

The writer indicates the limits of variations and by the dashed and dotted (——– – ———) outline of the field in Figure 3.

The observations above as to causes of variations with SiO_2 apply also to Al_2O_3.

With Al_2O_3 a definite minimum of potential is found. As preheating was made more thorough, the following definite tendencies were noted:

To lower the temperature of minimum potential;

Above the temperature of minimum potential, to raise the potential at any given temperature.

The writer wishes to express his thanks and to acknowledge his obligation to Prof. George W. Sherman of the Department of Physics of Purdue University for advice and assistance throughout this investigation.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF SIGMA XI, CHICAGO, JUNE 21, 1933

The first meeting of the Executive Committee for 1933 was held at the University Club, Chicago, June 21, 1933. The meeting was called to order at 10.00 A.M. by President Wilson. Those present were: President Wilson, Secretary Ellery, Treasurer Pegram, Professor Cole, Professor Leuschner, and Mr. Donald Sweet, representing the alumni.

Business was transacted as follows:

1. ALUMNI RESEARCH FUND:

The Committee was of the opinion that in order to reduce expenses of circularizing the alumni in the interests of this fund, the next issue of the QUARTERLY should contain a special blank form soliciting contributions and providing for signature and address of contributor.

The Committee authorized the Committee on Award of Grants-in-Aid to expend for the academic year 1933-34 the sum of $1,000.00 in support of research.

2. PETITIONS:

a. *Wesleyan University:*

An informal petition presenting full information about the resources, equipment, and scientific faculty of Wesleyan University, Middletown, Connecticut, was presented. Pending further action, the Committee instructed the secretary to ascertain from Prof. L. C. Dunn of Columbia, President Conant of Harvard, and also from the deans of some graduate schools in institutions neighboring to Wesleyan, their opinions about the quality of scientific work done at this institution, and report to the meeting of the Executive Committee in Boston in December.

b. *Smith College:*

It was

Voted—To send official visitors to the institution to make a survey and report at the Boston meeting of the Committee. President Wilson appointed Prof. L. C. Dunn of Columbia, and Prof. Kirtley F. Mather of Harvard.

c. *Tulane University:*

The Committee

Voted—To request the group at Tulane to present a formal petition for possible consideration of the convention to be held in Boston in December 1933.

d. *University of Denver:*

The Committee asked Professor Leuschner to make an unofficial visit to the university at his convenience before the December meeting of the Committee.

e. *University of Hawaii:*

The Committee directed the secretary to recommend to the group of petitioners at this university that they form a territorial Sigma Xi club, giving them the option of organizing a territorial alumni chapter with the university as its nucleus.

f. *Massachusetts Institute of Technology:*

The Committee

Voted—That the group of petitioners be requested to present a printed petition for possible action at the next convention.

3. Certificates of Award for Research:

The secretary informed the Committee that eleven institutions had submitted theses and records of the writers, in competition for a certificate of award from the national society. It was

Voted—a. That as a principle the theses should be read by a committee in some one institution, a different institution each year.

b. That for the present year the theses be read by a committee at Union College and the Research Laboratory of the General Electric Company.

4. Relation of Sigma Xi Clubs to the National Organization:

The secretary raised the question regarding the relation of Sigma Xi clubs to the national organization. There are now thirty clubs in as many institutions. Some of them are very active and enthusiastic, holding stated meetings and making reports to the secretary's office. Some of them are consistently represented by a delegation at the annual convention. At present there is no close relationship between the clubs and the national organization. There is no record on the files of the secretary's office of the membership. With few exceptions the members of the club do not receive the official journal of the society.

After considerable discussion it was

Voted—That the secretary be directed to correspond with those clubs whose activities and interest and enthusiasm warrant the suggestion of the national board, recommending to them the possibility of forming an alumni chapter in their locality, and stating that the alumni chapters have all the rights and privileges of institutional chapters except that the number of elections in one year shall not exceed a number previously set for the chapter by the Executive Committee.

5. SEMI-CENTENNIAL:

A possible program for the semi-centennial was fully discussed. It was suggested:

a. A morning session might well be given to:

1. Greetings from the President of Cornell University and from a representative of the Cornell Chapter selected by the chapter;

2. A history of the society;

3. A presentation of those of the original founders who are still alive;

4. An historical address on "Ancient and Modern Ways of Awarding Honors."

b. Several sorts of programs for an afternoon meeting were suggested:

1. That the fields of science recognized by Sigma Xi might be grouped into four divisions—the physical sciences, mathematics, astronomy; the sciences of the earth; biology, anthropology and medicine; engineering—and that addresses be given by some representative of each of the four groups on the subject of how research work in one field within the group had been of assistance to research work in another field within the same group.

2. That two prominent men be asked to take the affirmative and negative sides of the question, "Has Science Research Justified Itself?"

3. That there be two addresses—one on "The place of the scientist fifty years ago," and one on "The place of the scientist today."

4. That several individuals be asked to give demonstration lectures, using for experiments apparatus of the early days of Sigma Xi and the modern apparatus; and that chapters might be invited to participate by suggesting for these demonstrations apparatus now in their possession.

c. For the evening session it was recommended that someone, perhaps some well-known philosopher, should give an address on "The Place of Science in Man's Mental and Moral and Spiritual Progress."

(The secretary was directed to submit these recommendations to chapters and ask for suggestions and recommendations.)

6. SEMI-CENTENNIAL AWARDS FOR RESEARCH:

The secretary called the attention of the Committee to the fact that the Atlantic City Convention voted that the income from invested funds of the Society should be segregated for the purpose of making awards for research now in progress, and that the first award should be made at the semi-centennial. The Committee

Voted—That President Wilson name a committee to study and propose methods of procedure in connection with such award or awards.

The Committee also

Voted—That the Society should take the occasion of its semi-centennial to pronounce citations for meritorious service in promoting research, selecting for such citation one individual from each of the nine scientific fields which Sigma Xi represents; that in selecting the individual for such citation all chapters be asked to name candidates to the Executive Committee, and that the chapters should not limit their candidates to their own locality.

7. THIRTY-FOURTH ANNUAL CONVENTION:

The secretary announced that the Thirty-fourth Annual Convention of the Society would be held in Boston in December in connection with the meetings of the A. A. A. S.

8. BUDGET:

The treasurer presented the annual budget for 1933.

Secretary's office, salaries and expenses	$4,100
Treasurer's office	200
QUARTERLY	2,500
Officers' travel expenses	1,200
Engraving charters	100
Total	$8,100

9. INVESTMENTS:

The Committee

Voted—To continue the treasurer's authority to make investments of the Society's funds.

10. TRANSFER OF FUNDS:

The Committee authorized the treasurer to transfer from the general funds of the Society a sufficient sum to meet the commitments of the Society in connection with grants-in-aid for 1932-33.

EDWARD ELLERY.

IN MEMORIAM

Harold De Forest Arnold, director of research of Bell Telephone Laboratories, died early in the morning of July 10, of a heart attack. Doctor Arnold was born in Woodstock, Conn., on September 3, 1883, and received his undergraduate training at Wesleyan University (Conn.). After further graduate work at the University of Chicago under Prof. R. A. Millikan and a year as a professor at Mt. Allison University, he received the degree of doctor of philosophy from Chicago in 1911. Then entering the Research Laboratories of the Bell System he was one of the scientists who laid the foundation for what is now Bell Telephone Laboratories, Inc. His contributions to knowledge have been in the field of telephone transmission, thermionics, and magnetics. In the field of thermionics he was one of the earliest scientific workers and was the first to appreciate the necessity for a high vacuum in the three-element thermionic tube. Other contributions to this art were the development and application of methods for obtaining such a vacuum; recognition of the existence and the importance of the space charge effect of electrons in such a device and the calculation of the magnitude of this effect and methods for its adaptation to commercial purposes. He developed designs for vacuum tubes and methods for their manufacture so that tubes could be made to meet the telephonic requirements of reliability and ease of maintenance. This work included the development, under his immediate direction and at his suggestion, of an oxide-coated filament as a source of electrons within this tube. He had charge of the adaptation of the tubes to the telephonic problem of long-distance wire telephony and also of radio telephony. In recognition of these achievements, Doctor Arnold was awarded the John Scott Medal in 1928.

The stimulating guidance and personal contributions of Doctor Arnold were also responsible for the development in Bell Telephone Laboratories of the magnetic alloys, permalloy and perminvar. The first of these has an exceptionally high susceptibility to magnetism, many times that of the various materials previously available. In the form of a continuously applied loading to submarine telegraph cables, it has increased their message carrying capacity more than fivefold while its application to magnetic structures such as telephone receivers and transformers has been of great value in the undistorted transmission of sound. The alloy, perminvar, has the additional characteristic of being but little affected by superposed steady magnetizing forces so that it finds an important field of application in the cores of loading coils whose windings carry direct currents as well as the alternating currents of telephony.

As the research activities of the Bell System broadened his responsibilities were likewise broadened in scope with corresponding increase in staff for whose work he has been responsible. Under his efficient direction, not to mention his very definite contribution of ideas, fundamental research work upon many phases of the communication art has been carried on. These have notably advanced the whole telephone art both wire and radio; they have made available new methods in land wire telegraphy; in submarine cable telegraphy they

have furnished a new type of cable with appropriately modified methods of operation; they have given new methods of recording sounds, making possible improved phonograph records and making practical the so-called talking movie; and finally, not to extend the statement further, this work finds more or less direct application to the problem of those with impaired hearing.

During the World War, Doctor Arnold was commissioned a captain in the Signal Corps and contributed effectively to the work in submarine detection.

Doctor Arnold was a member of Phi Beta Kappa, Sigma Xi, and Gamma Alpha Fraternities, and of the Franklin Institute, the American Chemical Society, and the American Association for the Advancement of Science. He was a Fellow of the American Institute of Electrical Engineers, of the American Physical Society, and of the Acoustical Society of America; a member of the last named society's Executive Council and its representative on the governing board of the American Institute of Physics.

CHAPTER OFFICERS

List Furnished by the Secretaries of the Chapters

Chapter	President	Vice-President	Secretary	Treasurer
Cornell	Robert Matheson	L. A. Maynard	G. E. Grantham	A. J. Hennig
Rensselaer	A. W. Bray	J. L. Rosenholtz	F. M. Sebast	H. E. Stevens
Union	C. B. Hurd	E. S. C. Smith	F. J. Studer	F. J. Studer
Kansas	H. H. Lane	C. M. Young	E. L. Treece	H. E. Jordan
Yale	I. V. Hiscock	L. E. Seeley	R. K. Warner	R. D. Coghill
Minnesota	D. G. Paterson	G. O. Burr	F. B. Hutt	Alice Biester
Nebraska	B. C. Hendricks	T. A. Kiesselbach	E. N. Anderson	M. G. Gaba
Ohio	J. F. Lyman	E. M. Spieker	F. A. Hitchcock	F. A. Hitchcock
Pennsylvania	H. C. Bazett	C. P. Olivier	E. P. Helwig	P. A. Caris
Brown	A. A. Bennett	R. B. Lindsay	G. L. Church	W. R. Benton
Iowa	J. H. Bodine	J. A. Eldridge	A. C. Tester	Roscoe Woods
Stanford	G. M. Smith	C. H. Danforth	P. R. Farnsworth	V. E. Hall
California	T. H. Goodspeed	E. O. Lawrence	G. E. Troxell	S. F. Cook
Columbia	D. E. Lancefield	J. S. Morgan	G. M. Kay	G. M. Kay
Chicago	F. C. Koch		W. C. Pierce	C. G. Cronin
Michigan	A. H. White	E. H. Kraus	O. F. Duffendack	S. S. Atwood
Illinois	F. L. Stevens	H. Woodrow	R. F. Paton	R. C. Fuson
Case	H. B. Dates	C. L. Eddy	T. D. Owens	T. M. Focke
Indiana	H. T. Briscoe	E. L. Yeager	P. M. Harmon	P. Weatherwax
Missouri	M. M. Ellis	M. J. Guthrie	F. F. McKenzie	G. F. Breckenridge
Colorado	J. W. Broxon	E. H. Brunquist F. Eaton	H. B. Van Valkenburgh	W. K. Nelson
Northwestern	R. H. Gault	A. C. Ivy	H. B. Ward	M. Carlson
Syracuse	D. P. Randall	C. C. Carpenter	R. R. Hirt	E. T. Aptel
Wisconsin	F. Daniels	J. Stebbins	J. B. Kommers	H. R. Aldrich
Univ. of Wash.	E. A. Loew	C. L. Utterback	R. H. Gundlach	R. B. Van Horn
Worcester	K. G. Merriam	T. H. Morgan	W. E. Lawton	W. L. Phinney
Purdue	H. E. Enders	L. V. Ludy	R. H. George	Marguerite Mc
Washington Univ.	G. E. M. Jauncey	F. W. Bubb	W. D. Shipton	R. R. Tucker
Dist. of Columbia	A. Wetmore	Wm. Bowie	Miss Vinnie Pease	Wm. Lerch
Texas	G. W. Goldsmith	H. R. Henze	Jet C. Winters	R. H. Cuyler
Mayo Foundation	H. F. Helmholz	J. C. Masson	J. L. Bollman	J. L. Bollman
N. Carolina	R. E. Coker	E. T. Browne	E. L. Mackie	E. L. Mackie
N. Dakota	R. R. Hitchcock	G. A. Talbert	R. C. Staley	R. C. Staley
Iowa State College (formerly *Ames*)	B. W. Hammer	J. W. Woodrow	J. L. Lush	H. E. Biester
Rutgers	H. E. Starr	T. C. Nelson	R. d'E. Atkinson	M. A. Chrysler
McGill	W. G. McBride	J. B. Collip J. J. O'Neill	D. L. Thompson	C. L. Huskins
Kentucky	F. E. Tuttle	H. H. Downing	E. M. Johnson	J. S. McHargue
Idaho	Ella Woods	J. Nordby	J. Buchanan	A. M. Sowder
Swarthmore	W. J. Scott	M. W. Garrett	H. J. Creighton	H. J. Creighton
Oregon	L. F. Henderson	I. Manville	Rosalind Wulzen	F. L. Shinn
Virginia	J. K. Roberts	C. C. Speidel	J. E. Kindred	J. E. Kindred
Johns Hopkins	A. H. Pfund	A. M. Chesney	M. W. Pullen	F. D. Murnaghan
Calif. Inst. of Technology	J. A. Anderson	R. R. Martel	W. R. Smythe	R. T. Knapp
New York	R. R. Renshaw	C. W. Lytle	H. G. Lindwall	H. G. Lindwall
Cincinnati	W. Bucher	R. E. Oesper	S. B. Arenson	S. B. Arenson
Mich. State	R. C. Huston	Marie Dye	V. G. Grove	R. E. Marshall
Arizona	G. E. Davis	E. H. Warner	R. B. Streets	R. B. Streets
Lehigh	J. S. Long	A. Ford	P. L. Bayley	R. D. Billinge
Maryland	L. B. Broughton	J. E. Metzger	M. M. Haring	M. M. Haring
Kansas State	L. E. Conrad	D. C. Warren	C. W. Colver	J. L. Hall
Col. of Medicine, Univ. of Illinois	R. H. Jaffe	A. G. Cole	W. H. Welker	I. Pilot
Pennsylvania State	E. D. Walker	R. A. Dutcher	W. B. Mack	W. L. Henning
Oklahoma	A. I. Ortenburger	N. A. Court	L. E. Swearingen	L. E. Swearingen
State Col. of Wash.	J. L. St. John	R. L. Webster	J. G. Woodburn	J. G. Woodburn
Wyoming	J. W. Scott	S. H. Knight	Carl S. Gilbert	Carl S. Gilbert
Rochester	A. S. Gale	W. S. McCann	Q. D. Singewald	Q. D. Singewald
Pittsburgh	O. E. Jennings	C. G. King	R. T. Hance	A. G. Worthing
Harvard	G. H. Parker	J. B. Conant	K. F. Mather	W. L. Crum
Western Reserve	H. S. Booth	J. A. Doull	W. M. Krogman	A. H. Hersh
Princeton	G. H. Shull	E. N. Harvey	P. MacClintock	F. R. Caley
Duke	L. A. Bigelow	Ruth Addoms	J. B. Rhine	Bert Cunningham
California At Los Angeles	S. J. Barnett	B. M. Varney	E. K. Soper	H. W. Stone

SIGMA XI CLUBS

Club	President	Vice-President	Secretary	Treasurer
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.....	T. R. Garth.....	.....	E. A. Engle.....	E. A. Engle
...College.	S. H. Grat.....	J. R. Haag.....	W. E. Milne.....	W. E. Milne
.....	G. S. Dodds.....	H. M. Fridley.....	L. M. Thurston	L. M. Thurston
.....	W. F. Dove.....	M. Freeman.....	M. D. Sweetman....	M. D. Sweetman
.....	B. V. Christensen...	R. W. Ruprecht.....	H. H. Germond.....	H. H. Germond
...Agricul.	C. Rohwer.....	.....	H. E. Brewbaker....	H. E. Brewbaker
...Dakota...	E. P. Rothrock.....	.....	.....	.....
.....	E. C. Timms.....	A. D. McKinley.....	W. Whitcomb.....	W. Whitcomb
.....	E. B. Carmichael....	T. E. Hunt.....	J. L. Kasner.....	Marie C. D'Amour
.....	L. C. Price.....	.....	L. M. Turner.....	L. M. Turner
...at Davis..	P. W. Gregory.....	.....	F. A. Brooks.....	F. A. Brooks
.....	Elton Quinn.....	I. B. Burns.....	T. C. Adams.....	.....
...University..	R. H. Goddard.....	.....	P. M. Roope.....	P. M. Roope
.....	L. F. Yntema.....	W. H. Griffith.....	J. E. Case.....	.....
...College....	F. A. Ferguson.....	W. L. Kulp.....	W. N. Plastridge...	W. N. Plastridge
...University..	Clarence Kreger.....	.....	B. M. Davis.....	.....
.....	A. S. Edwards.....	.....	M. W. Lowry.....	.....
.....	W. H. Stewart.....	.....	J. S. Gold.....	J. S. Gold
.....	G. H. Cartledge.....	.....	W. L. Tressler.....	W. L. Tressler
...A. and ...	W. A. Craft.....	J. H. Cloud.....	J. E. Webster.....	J. E. Webster
...State ...	W. McK. Martin....	J. A. Nelson.....	Jessie Richardson....	Jessie Richardson
...College....	L. R. Waldron.....	D. S. Dedrick.....	C. I. Nelson.....	C. I. Nelson
.....	R. C. Goodwin.....	W. H. Abbitt.....	G. W. Woodbury....	.....
.....	F. O. Smith.....	G. D. Shallenberger..	C. W. Waters.....	.....
...Poly-...	P. C. Scherer.....	.....	.....	.....
...China....	W. H. Adolph.....	Y. C. Mei.....	A. P. T. Sah.....	A. P. T. Sah
.....	W. A. Fletcher.....	.....	.....	.....
...College...	J. E. Fuller.....	.....	C. R. Fellers.....	C. R. Fellers

OFFICIAL ANNOUNCEMENTS

SIGMA XI EMBLEMS

All insignia of the Society are available only through the office of the National Secretary. They are made in various styles and sizes, and in white and yellow gold. Orders for these insignia are issued through chapter secretaries, and must be *prepaid*. Information about styles and prices may be obtained from chapter secretaries or the National Secretary.

DIPLOMAS FOR MEMBERS AND ASSOCIATES

These diplomas are available in any quantity at 9 cents each. Orders should be sent to the National Secretary, should specify whether for members or associates, and should be accompanied by check.

INDEX CARDS

Index cards for newly elected members and associates are available *gratis* upon requisition from chapter secretaries to the National Secretary. These cards should be made out in duplicate, one set being retained for chapter files and one set being sent to the National Secretary for filing in the permanent records of the national organization.

NATIONAL CONSTITUTION

Printed copies of the National Constitution, containing all amendments to date, and all recent interpretations as made by the national officers on request of chapters, are available at 9 cents each from the National Secretary.

CHANGES OF ADDRESSES

Chapter secretaries are asked to send to the National Secretary in October of each year changes in their enrollment lists as follows: 1. Names and addresses to be deleted from the previous list; 2. Names and addresses to be added to previous list; 3. Changes of addresses of those on previous list who may have moved to a new address since the list was submitted.

EDWARD ELLERY,
National Secretary, Sigma Xi,
Union College,
Schenectady, N. Y.